MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2022/2023

PTH0016 MODERN PHYSICS AND THERMODYNAMICS

(Foundation in Engineering)

4 JULY 2023
9.00 A.M. – 11.00 A.M.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 6 pages, including the cover page.
2. Answer all questions.
3. Write your answers on answer booklet provided.
4. Show all relevant steps to obtain maximum marks.

QUESTION 1 (15 MARKS)

a) Sketch the following: concave mirror, convex mirror, converging lens and diverging lens and label them accordingly. [4 marks]

b) What do you understand by the following terms. You can use a diagram as an aid.
   (i) Law of reflection. [1 mark]
   (ii) Snell's law [1 mark]
   (iii) Total internal reflection [1 mark]
   (iv) Constructive interference [1 mark]

c) A two-slit experiment with slits separated by 50.0×10^{-5} m produces a second-order maximum at angle of 0.10°.
   (i) Find the wavelength of the light used in this experiment. [1 mark]
   (ii) If the slit separation is increased, but the second–order maximum stays at the same angle, does the wavelength increase, decrease, or stay the same? Explain. [1 mark]

d) A beam of light is passing through air to oil to water.
   (i) If the angle of incidence in the air is 40°, find the angle of refraction in the water. The index of refraction for the oil is 1.45. [1 mark]

   (ii) If possible, find the angle of incidence in air such that the beam will not enter the water. [1 mark]

   (iii) Suppose that the direction of the beam is reversed. If possible, find the critical angle in water so that the beam will not enter the air. [1 mark]

e) An object is placed 7.10 cm to the left of a diverging lens whose focal length is 5.08 cm. Find the image distance and determine whether the image is real or virtual. [2 marks]

Continued...

QUESTION 2 (10 MARKS)

a) A hydrogen atom undergoes a transition from the third excited state ($n = 4$) to the second excited state ($n = 3$).

(i) Find the energy of the emitted photon in joules. [2 marks]

(ii) What is the wavelength of the emitted photon? [2 marks]

(iii) For an unexcited ($n = 1$) hydrogen atom, what is the energy required (in eV) to free the electron in the atom? [1 mark]

b) (i) In a photoelectric effect experiment, what is the reason the air in the glass tube is removed? [1 mark]

(ii) The work function of aluminium is 4.28 eV. What do you understand by work function? [1 mark]

(iii) Determine if photoelectrons will be emitted if the aluminium is illuminated with a light of wavelength 330 nm. [3 marks]

QUESTION 3 (15 MARKS)

a) Briefly explain what the following terms mean.
(i) Isotope [1 mark]
(ii) Half-life [1 mark]

b) Calculate the mass of a sample of pure $^{40}_{19}\mathrm{K}$ with an initial decay rate of $2.0\times10^{5}\ \mathrm{s}^{-1}$. The half-life of $^{40}_{19}\mathrm{K}$ is 1.28×10^{9} year. [4 marks]

c) What is the energy emitted in the following decay process?
(i) $^{218}_{84}\mathrm{Po} \rightarrow {}^{214}_{82}\mathrm{Pb} + {}^{4}_{2}\mathrm{He}$ [2 marks]

(ii) $^{218}_{84}\mathrm{Po} \rightarrow {}^{218}_{85}\mathrm{At} + {}^{0}_{-1}\mathrm{e}$ [2 marks]

(Atomic mass values:
$^{218}_{84}\mathrm{Po} = 218.008965\mathrm{u}$, $^{214}_{82}\mathrm{Pb} = 213.999798\mathrm{u}$, $^{4}_{2}\mathrm{He} = 4.002602\mathrm{u}$,
$^{218}_{85}\mathrm{At} = 218.00868\mathrm{u}$)

Continued...

QUESTION 4 (15 MARKS)

a) What do you understand by the following?

(i) Thermal equilibrium [1 mark]

(ii) Convection [1 mark]

(iii) Latent heat of vaporization [1 mark]

(iv) First law of thermodynamics [1 mark]

(v) Isobaric changes [1 mark]

b) It is desired to put an iron rim on a wooden wheel. The diameter of the wheel is 1.1000 m and the inside diameter of the rim is 1.0980 m. If the rim is at 20 °C initially, to what temperature must it be heated to just fit onto the wheel?
Given $\alpha_{\text{iron}} = 1.2 \times 10^{-5}\ ^{\circ}\text{C}^{-1}$

[2 marks]

c) Initially 48.0 g of ice at 0°C is in an aluminium calorimeter can of mass 2.0 g, also at 0°C. Then, 75.0 g of water at 80 °C is poured into the can. What is the final temperature?
Given $c_{\text{aluminium}} = 900\ \text{J/kg°C}$, $c_{\text{water}} = 4186\ \text{J/kg°C}$ and $L_{\text{ice}} = 336000\ \text{J/kg}$.

[3 marks]

d) One mole of ideal gas is undergoing a process of change in its states as given by the path *a-b-c* in the *PV* – diagram of **Figure Q4(d)** below.

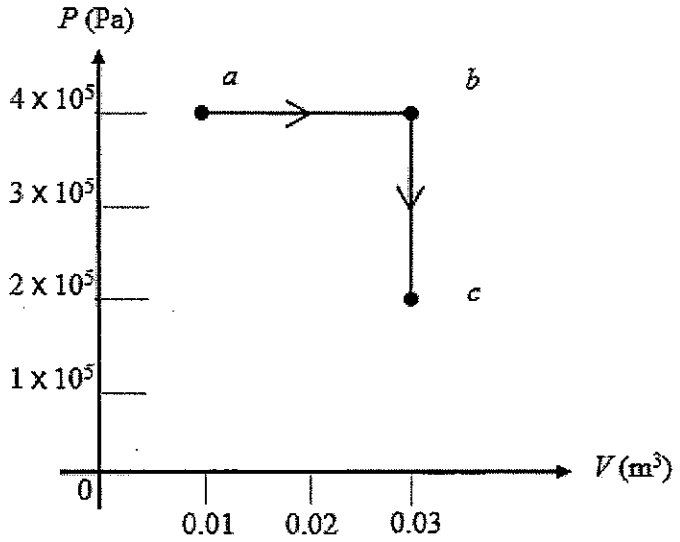

Figure Q4(d)

(i) Determine the temperatures of the gas at points *a*, *b*, and *c*.

[3 marks]

(ii) Compare the internal energy of the gas at points *a*, *b*, and *c*. Briefly justify your answer.

[2 marks]

End of paper.

APPENDIX

LIST OF PHYSICAL CONSTANTS

Electron mass,	m_e	=	9.11×10^{-31} kg
Proton mass,	m_p	=	1.67×10^{-27} kg
Neutron mass,	m_n	=	1.67×10^{-27} kg
Magnitude of the electron charge,	e	=	1.60×10^{-19} C
Universal gravitational constant,	G	=	6.67×10^{-11} N m^2 / kg^2
Universal gas constant,	R	=	8.314 J/mol K
Hydrogen ground state,	E_0	=	13.6 eV
Boltzmann's constant,	k_B	=	1.38×10^{-23} J/K
Compton wavelength,	λ_c	=	2.426×10^{-12} m
Planck's constant,	h	=	6.63×10^{-34} J s
		=	4.14×10^{-15} eV s
Speed of light in vacuum,	c	=	3.00×10^8 m/s
Rydberg constant,	R_H	=	1.097×10^7 m^{-1}
Acceleration due to gravity of earth,	g	=	9.80 m/s^2
1unified atomic mass unit,	1 u	=	931.5 MeV/c^2
		=	1.66×10^{-27} kg
1 electron volt,	1 eV	=	1.60×10^{-19} J
Avogadro's number,	N_A	=	6.02×10^{23} mol^{-1}
Threshold of intensity of hearing,	I_0	=	1.0×10^{-12} W/m^2
Coulomb constant,	$k = \frac{1}{4\pi\varepsilon_0}$	=	9.0×10^9 N m^2 /C^2
Permittivity of free space,	ε_0	=	8.85×10^{-12} C^2/N m^2
Permeability of free space,	μ_0	=	$4\pi \times 10^{-7}$ T m/A
1 atmosphere pressure,	1 atm	=	1.013×10^5 N/m^2
		=	1.013×10^5 Pa
Wien's displacement constant		=	2.90×10^{-3} mK
Speed of sound in air		=	343 m/s
Refractive index of air/vacuum	n	=	1.0
Earth: Mass,	M_E	=	5.97×10^{24} kg
Radius (mean),	R_E	=	6.38×10^3 km
Moon: Mass,	M_M	=	7.35×10^{22} kg
Radius (mean),	R_M	=	1.74×10^3 km
Sun: Mass,	M_S	=	1.99×10^{30} kg
Radius (mean),	R_S	=	6.96×10^5 km
Earth-Sun distance (mean),		=	149.6×10^6 km
Earth-Moon distance (mean),		=	384×10^3 km
First Bohr Raduis,	a_o	=	0.053 nm

LIST OF FORMULAS

$$\sin\theta_1 + \sin\theta_2 = 2\sin\left(\frac{\theta_1+\theta_2}{2}\right)\cos\left(\frac{\theta_1-\theta_2}{2}\right)$$

$$\cos\theta_1 + \cos\theta_2 = 2\cos\left(\frac{\theta_1+\theta_2}{2}\right)\cos\left(\frac{\theta_1-\theta_2}{2}\right)$$

$$\sin\left(\theta+\frac{\pi}{2}\right) = \cos\theta$$

$\sin\theta \approx \tan\theta \approx \theta \ \ rad$ for small angles

$D(x, t) = D_M \sin(kx \pm \omega t \pm \phi)$

$$v = \sqrt{\frac{F_T}{\mu}} \qquad v = \sqrt{\frac{\text{elastic property of the medium}}{\text{inertia property of the medium}}} \qquad v = (331 + 0.60T) \qquad v = f\lambda$$

$$f_n = \frac{nv}{2L} \qquad f_n = \frac{nv}{4L} \qquad \lambda_n = \frac{2}{n}L \qquad f' = f\left(\frac{v \pm v_o}{v \mp v_s}\right)$$

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \qquad \frac{1}{f} = (n-1)\left\{\frac{1}{R_1} + \frac{1}{R_2}\right\} \qquad f = \frac{R}{2}$$

$$d\sin\theta = m\lambda \qquad d\sin(\theta) = \left(m+\frac{1}{2}\right)\lambda \qquad a\sin(\theta) = n\lambda$$

$$\lambda_m.T = 0.2898 \times 10^{-2} \qquad I(\lambda, T) = \frac{2\pi c k_B T}{\lambda^4}$$

$$E_n = -\frac{mk^2e^4}{2\hbar^2}\left(\frac{1}{n^2}\right) \qquad r_n = \frac{\hbar^2}{mke^2}n^2 \qquad L = mvr_n = n\hbar$$

$$\frac{1}{\lambda} = R_H\left[\frac{1}{n_i^2} - \frac{1}{n_f^2}\right] \qquad \frac{1}{\lambda} = \frac{mk^2\ Z^2e^4}{4\pi\ c\hbar^3}\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right] \qquad \lambda = \frac{h}{p}$$

$$R = R_0e^{-\lambda t} \qquad \lambda = \frac{\ln 2}{T_{1/2}} \qquad Q = (M_X - M_Y - M_\alpha)\ c^2$$

$$pV = nRT \qquad k = \frac{R}{N_A} \qquad N = N_0e^{-\lambda t}$$

$$\frac{\Delta Q}{\Delta t} = -kA\frac{\Delta T}{\Delta L} \qquad \frac{\Delta Q}{\Delta t} = e\sigma AT^4 \qquad \frac{\Delta Q}{\Delta t} = IeA\cos(\theta)$$

$$\overline{KE} = \frac{1}{2}m\bar{v}^2 = \frac{3}{2}kT \qquad U = \frac{3}{2}nRT$$

$$Q = \Delta U + W \qquad W = \int dW = \int_{V_i}^{V_f} PdV \qquad W = P\Delta V$$